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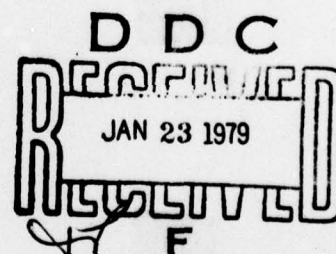
FOREIGN TECHNOLOGY DIVISION



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by

Chuang Fung



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FTD -ID(RS)T-1138-78

EDITED TRANSLATION

FTD-ID(RS)T-1138-78

1 August 1978

MICROFICHE NR: *FTD-78-C-001057*

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English pages: 10

Source: Hang K'ung Chih Shih, Nr. 7, July 1977,
pp. 16-19

Country of origin: China

Translated by: Linguistic Systems, Inc.

F33657-76-D-0389

Hung S. Wong

Requester: FTD/SDBS

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WP.AFB, OHIO.

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THE RELIABILITY OF FLYING MACHINES
AND ENVIRONMENTAL TESTINGS

Chuang Fung

Abstract : To guarantee the safe and reliable use of flying machines, besides the requirement of excellent design, a lot of testings are indispensable. Taking missiles as an example, this article briefly introduces the influence of environmental conditions on their reliabilities and related testing problems.

When our air force is guarding our own country, can we afford to have frequent mistakes? At the moment we are being attacked by the Imperialist, Socio-imperialist, can we stand it if our missiles do not work or break down on their way? No way! With regard to flying machines, especially when used as weapons, they must be reliable in order to fight our enemies, but flying machine is a very complicated system. An airplane or a missile is composed of thousands of parts. If one part breaks down, a wire disconnected or something goes wrong under its operating conditions, serious consequences could happen. Therefore, unlike the flowers in the green house that cannot stand the severely hot summer or cold winter, our flying machines have to work reliably in all kinds of conditions--day or night; winter or summer; at north or south; in air or at sea. How to minimise the mistakes of this complicated system during operation? According to the hypothesis of 'Differential Judgement by Reference', if we want the machine to work 'freely', we have to analyse the 'expected' obstacles and make further modifications, so that it can work under all adverse situations. Hence, in order to increase the reliability of the flying machines, firstly, we have to recognise these different possible situations. Then we choose the most adverse kinds of environmental conditions and try to reproduce them in the laboratory within which different parts of the machine or even the whole machine are being tested. A series of environmental testings enable us to detect the accuracy of the design or the quality of production, and the corrections are continuously under way. Hence environmental testing is one of the indispensable procedures in increasing the reliability of flying machines.

Environmental Conditions

The operation of missiles can be divided into two stages-- ground and air.

During the ground stage, the missiles can be transported, stored, installed, checked or ready for guarding purpose. In this stage, the missiles are principally under natural environmental conditions and have to face the different climatic changes. For missiles with guarding purpose, they have to encounter even more adverse environmental situations. This stage usually takes a long time, hence is a tough testing for the missiles.

The natural environment of the earth is very complicated. As our country is a big continent, there exist different kinds of climates. Places in our country with hot and humid climate include Lay Chao Peninsula, Hi Nan Island, Southern Taiwan and the Isles of South Sea. North of them have sub-tropical and temperate climates, and north of Hay Lane River belong to the sub-polar zone. Hence the climatic conditions are really complicated.

There are a lot of climatic factors which include temperature, humidity, pressure, wind speed, sand erosion, amount of rainfall and snow, fog, saline fog and so on. Among them, temperature, humidity and saline fog have the greatest influences on missiles.

At high temperatures, the metal expands; plastic products disintegrate, properties of electric parts change; lubricating fluid becomes less sticky and the system will overheat. They all can affect the effectiveness of the missiles. In our country, the temperature in many regions reaches over 40°C . Some particular locations have temperature over 47°C . Among different countries in the world, Libia, the capital of Africa, once had temperature over 58°C . If the sun shines directly on the missiles surface, their temperature may reach 75°C .

On the other hand, low temperature makes the materials contract and becomes brittle; specific heat of electrical parts and properties of semi-conductors change; lubricating fluid becomes more viscous and locks the movable parts of the missiles. At the north and northwest part of our country, the temperature in winter usually reaches -40°C , and the lowest record was -50°C .

The relative humidity is another important factor on missiles operation. Low humidity is characteristic to the desert area (hot dry zone). Under this condition, wood, paper and fibrous materials are usually dry and brittle. In contrary, high humidity always occurs in tropical, subtropical and temperate regions. In the rainy seasons of tropics, a temperature about 25°C usually corresponds to a relative humidity of 100%. This is due to the saturation of water vapor in the air and gives rise to fog. It may decrease the insulation resistance of the electronic system and induce decay of the composing materials. If temperature increases at the same time, the decay will be accelerated. Furthermore, under these conditions, mould will grow fast on certain materials and lead to their further distruction. In condition with temperature of 20°C and humidity of 80% for 12 hours, besides the probable influence of the water vapor, the growth of mould and its damage also increase.. This is very ~~quite~~ serious. In our country, some places have this kind of condition for over 150 days a year.

In ocean area, saline fog is one of the factors that cause metal damage. Since water vapor contains salt, it can produces a serious problems. Hence if missiles are being used in ocean area, such problem has to be considered.

Apart from the above natural conditions, missiles have to experince the ~~impulse force~~ and vibration during their transportation, allocation and installation. Their influence depend on the frequency range of vibration, the magnitude of acceleration(g) and the time they persist. The above variables in turn depend on the routes of transportation (rail-road, highways, air, sea and so on), velocity of transportation, condition of the roads and the kinds of vehicles used. In general, the frequency of vibration is below 50 c.p.s. except in the case of air transportation which has a wider range of frequencies. The vibrational accerleration is usually within 1 g. In special situations such as movement over un-lating roads, it can reach over 3 g. (Fig. 1). When a train turns or runs off-track or its hooks disconnected suddenly, the accexleration may be over 4 g. In general, the experience of vibration and momentum changes during the ground stage is much less as compared with the flight stage.

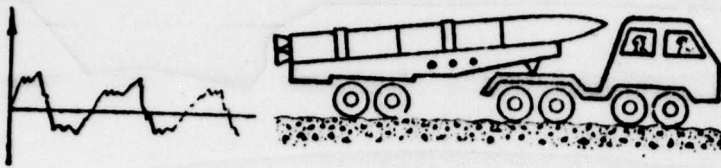


Diagram showing the vibration of the guided missile during transportation.

The *other* difference is that ground transportation is usually longer and lead to interconnecting hooks damage, dislocation

of component parts. Therefore, missiles have to pass through this lengthy challenge before they can be used during war time.

In addition to the above challenges, under special circumstances, such ^{as} occurrence of bombing nearby or during atomic war, the impulse and radioactivity produced have to be considered.

Flight stage: at this stage, the situation of the missiles is governed by their own motion and internal operations. They include firing, ultra-sound speed stage, ignition of the secondary engine, separation of sections, shutting off of the engine, free flight and return to the atmosphere. These conditions will generate vibration, momentum, noise disturbance, impulse, high temperature, low pressure and so on.

Vibration is one of the greatest obstacles for missiles at their flight stage. Because of the strong vibration, the normal function of the missiles would be interfered. Hence, in the production and design missiles, the vibrational environment should be emphasised. The vibration is mainly caused by the noise of the engines, the air current on upon the missile surface, and related to the ways of installation of the power system. The most severe vibration occurs at the time of firing, the ultra-sound stage and the return to the atmosphere. At other situations, the vibrational rate is relatively small. During firing, the vibration of the engine passes through the missile frame to the connecting sections. The greatest vibration occurs around the engine, usually at 20-30 g. The frequency ranges from several c.p.s. to a few thousand c.p.s. Due to the absorption of the vibration via the connecting portions, its magnitude will decrease gradually at regions away from the engine to about 15 g., and much smaller at the end portion. The noise produced from the jet engine and the

the head portion. The noise produced from the jet engine and the surface air current is the main source of vibration of the joining parts. Due to the accelerating propelling force of the engine, the noise produced can be tremendous. The frequency of vibration can increase from several tens of c.p.s. to over 10,000 c.p.s. In general, the sound energy from the shouting of 33,000 people is about 1,000 joules while that from the engine at the time of ignition is over 5,000 J. The sound intensity of the latter is over 167 decibels. Even at the head portion, this value reaches 152 db. (Fig. 2). Via the air transmission, such sound intensity can cause weakening and damage to the region around the engine.

The production of impulse is characterised by a great change of momentum in a very short time. The sudden propelling force at the time of ignition and the explosion during separation of sections can produce a very great impulse force. In about four to eight milliseconds, this impulse can be up to around 100 g. Those self vibrational frequencies that can superimposed with the impulse produced by a particular section can be hazardous.

The acceleration of the missiles is governed by the propelling force and the projectile curvature. Besides its acceleration pointing away from the centre of curvature, there is also horizontal accelerations when the missile turns. Both together can produce an acceleration of over 100 g.

As the head portion of the missile goes back to the atmosphere, high temperature is a serious problem. The friction of the atmosphere with the missile at high speed can produce a hot current of over 13,000 cal. per square meter per second, and causes severe burning damage.

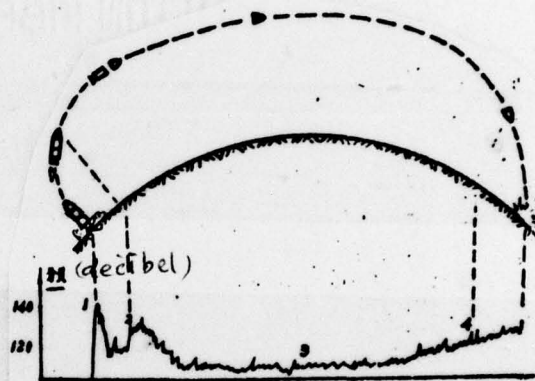


Fig. 2. Typical sound record of the head portion of missiles.
 1. Sound production from engine during firing
 2. The greatest vibration
 3. Freely flying stage
 4. Sound production at time of return

Besides, the intensity of the noise from the missile head at its re-entry into the atmosphere could be higher than that from the engine. Furthermore, the missile head also encounters situations of low pressure, low temperature, cosmic radiation, particular current, etc. in the upper atmosphere.

The above description is only a generalisation of the operating situations of the missiles. Different types of missiles have their own operational requirements. Hence, the environmental conditions of missiles are determined by their particular usage and a lot of statistical analyses and calculations are required. Finally, modifications can take place from the results of practical testings.

Environmental Testings

From the above analyses, missiles will be operated in an adverse environment. To confirm their use under such conditions, different component parts or the entire product have to undergo many necessary environmental testings. They include vibration, impulse, transportation, noise production, high/low temperature, humidity, saline fog, low pressure, acceleration and other special environments. The following is a brief introduction of a few methods of environmental testings.

^{mal}
~~Vibrational~~ testing: it is done by an imitation of the probable vibration produced during the ground transportation and flying stage. The equipment used is a vibrational platform, but it can also be done by actual transportation testing. The vibrational platform can be divided into four types--- mechanical, hydraulic, electromagnetic and electrical. A particular choice depends on the dimension, weight of the testing object and the different testing requirements.

The mechanical type is the simplest one. A direct current machine is used to rotate a pair of eccentrically arranged wheels. It produces a to and fro and up and down vibration of the platform. ^{its} ~~its~~ vibrational frequency depends on the speed of the rotating machine while its amplitude is governed by the relative angle of the wheels. Generally, this kind of platform operates with a frequency of 5-100 c.p.s., an amplitude up to 20mm. and an acceleration of about 30 g. It does not

carry heavy weights, usually below 100kg.

The hydraulic type works by the action of high pressure on a liquid. This pressure is transmitted to some movable cylindrical tubes and produces a to and fro motion. The characteristics of this type are that it generates a tremendous power (tens of tons), large amplitude (as great as 250 mm., frequency from 0-300 c.p.s., and its load can be several tons.

Until now, electromagnetic type is the most common one used. Its operation is analogous to the loudspeaker of a radio. The passage of the oscillating electrical signals through the movable coil within a magnet produces a to and fro motion (Fig. 3). Though this is a more complicated type, it is more versatile. It can be used for both longitudinal and transverse wave type of testings. In general, it has a wider range of frequencies, from 15-2,000 c.p.s. Its force produced can reach 20 tons. The load it carries depends on the size of the platform. The largest one can support a load of several hundred tons.

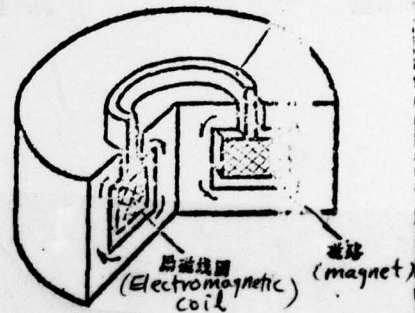


Fig.3 diagramatic representation of electro-magnetic platform.

Electrical type of platform makes use of a number of electrical voltage sources as the vibrating source. Its frequency range is 1,000-20,000 c.p.s., amplitude below 0.02 mm. It can give an acceleration of 1,000 g. This type is mainly used to test the accuracy of the acceleration transmitters and sensitizers.

Sound testings: there are a few ways to imitating the high sound intensities.

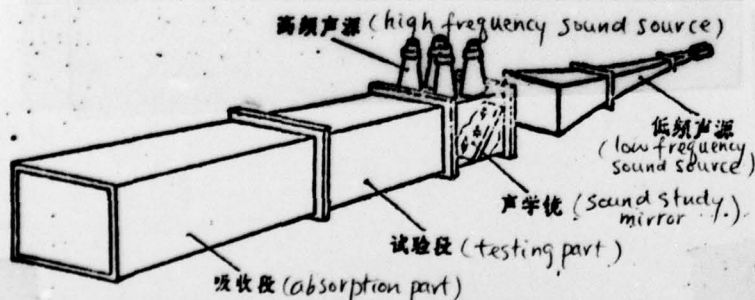
Stationary sound wave tube--- it works by the interference of the propagating and reflecting wave of a single frequency, and gives a high sound at a certain point of the tube. This type can produce a high intensity sound from a low-pitch source. Its frequency range is

limited by the size of the tube and mostly used at low frequencies. Its applications are for sound-testing of small parts and adjustment of sound transmitters and sensitizers.

Plane sound wave tube--- in this case, the reflection plane at one end of the stationary wave tube is converted into an effective absorbing body so that almost no sound wave is reflected. A small size tube of this type can produce a sound intensity of 140-180 db. from a moderate pitch sound. The testing frequency range is also limited by the size of the tube. It is usually used for testing small parts.

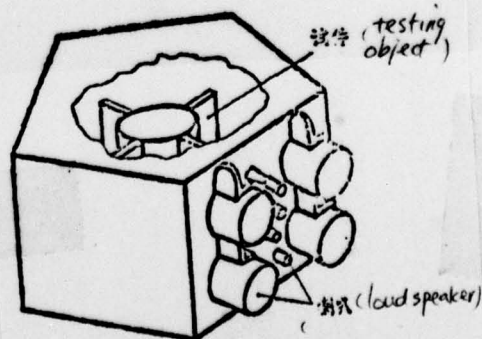
Propagating sound wave tube--- its difference from the plane wave one is that there is no requirement for absolute absorption of sound wave at one end and the frequencies are not limited by the size of the tube. It is used for exhausting testing of sound disturbance on the surface coating and the small apparatus and equipment of the missiles. It can reach an intensity of 160-170 db. By the same principle, it can imitate the entire sound environment of the missiles by utilizing the limited sound source during testings.

Interfering sound studio--- it makes use of electrical and gaseous sound sources in a closed, highly reflective studio. By the sound interference, it produces a particular intensity in a wide frequency range (Fig. 5). Its use is relatively common. It mainly



图四 行波管噪声试验设备示意图

Fig. 4. Diagrammatic representation of the equipment of the propagative sound wave tube



图五 混响室示意图

Figs. Interfering sound studio

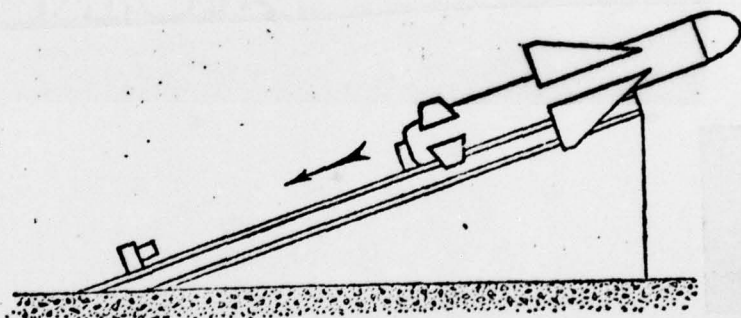
imitates the interior sound environment of the missiles. The size of can be so big that it can hold the entire space ship together with its rocket for testing purpose. The sound intensity reaches 150-160 db.

Piston type sound generator--- it produces a low frequency sound by the action of a piston in small, closed studio. Its frequency ranges from 0.01-50 c.p.s. The intensity generated is governed by the surface area of the piston and the distance of movement. Usually it can be up to 170 db. Its use is for moderate intensity testings and the adjustment of sound transmitter and sensitisers.

Impulse testing: the following ways are used to mimic the impulse environment.

Sliding type--- the testing object glides down at a given angle with the ground, collides with an obstacle at the bottom, and generates an impulse.(Fig.6)

Falling type--- the testing object is lifted to a given height and released suddenly. It collides with the absorber at the bottom (spring, rubber, etc.) and gives rise to an impulse.



图六 滑动式冲击机示意图

Fig.6. Diagrammatic representation of the sliding type of impulse testing machine

Impact type---the testing object rests on a plane platform. A heavy hammer is lifted to a given height or a particular angle and then released. The impact of the hammer and the platform produces an impulsive wave. It can be used to generate transverse wave type.

Pressurised-gun type--- it operates by a sudden release of air pressure on a piston containing the testing object, and produces a

highly impulsive reaction. The impulse can reach 2,400 g.

Centrifugal type--- using a constant velocity, the testing object is rotated on a rotating arm and a centrifugal impulse is produced. Its magnitude depends on the speed of rotation and the position of the object.

Other environmental imitations, including temperature, humidity pressure, saline fog testings, make use of the familiar techniques such as heating, freezing, vacuum and fog introduction. Hence they are described in this context.

In conclusion, the choice of testing programs and the environmental conditions of the entire testing are based on the functions of the different missiles. Due to the fact that there are usually two or more kinds of environment during the missile operation, more testings with environmental combinations gradually occur. This induces the more practical testings of missiles under the combined environmental influences.

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